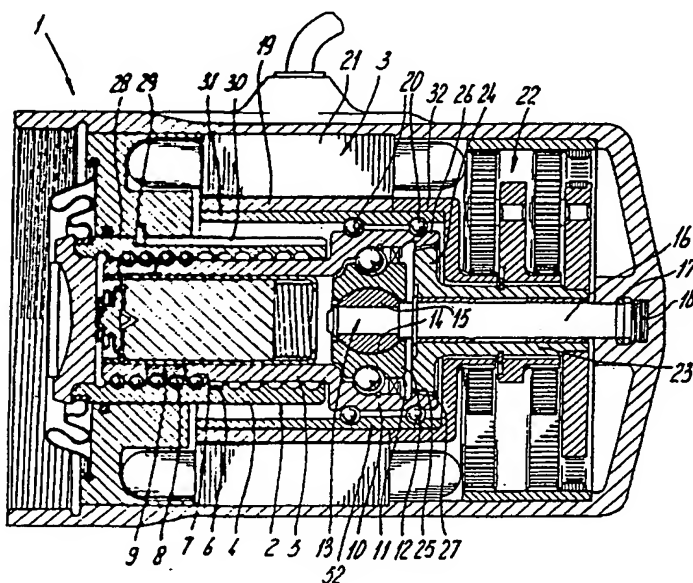




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/NL00/00053 (22) International Filing Date: 27 January 2000 (27.01.00) (30) Priority Data: 1011142 27 January 1999 (27.01.99) NL (71) Applicant (for all designated States except US): SKF ENGINEERING AND RESEARCH CENTRE B.V. [NL/NL]; Postbus 2350, NL-3430 DT Nieuwegein (NL). (72) Inventors; and (75) Inventors/Applicants (for US only): KAPAAN, Hendrikus, Jan [NL/NL]; Waterhoen 5, NL-3425 DM Nieuwegein (NL). VAN WINDEN, Johannes, Albertus [NL/NL]; Molenvaai 4, NL-3421 CM Oudewater (NL). ZWARTS, Jacobus [NL/NL]; Carmenlaan 5, NL-3438 VA Nieuwegein (NL). FUCKS, Thomas, Wilhelm [DE/DE]; Salierallee 54, D-52066 Aachen (DE). (74) Agent: JORRITSMA, Ruurd; Nederlandsch Octrooibureau, Scheveningseweg 82, P.O. Box 29720, NL-2502 LS The Hague (NL).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: COMPACT ACTUATOR



## (57) Abstract

An actuator comprises a housing (1) accommodating a screw mechanism (2) and a drive comprising a motor (3), said screw mechanism comprising a nut (4) and a screw (5) one of which is rotatably supported with respect to the housing, such that upon relative rotation of the nut and the screw a linear movement of one said nut and screw is obtained. At least a rotatable component of the drive, e.g. the rotor (19) of the motor, is rotatably supported on the screw which is rotatably supported with respect to the housing.

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Compact actuator

The invention is related to an actuator, comprising a housing which contains a screw mechanism and a motor, said screw mechanism comprising a nut and a screw, one of which is rotatably supported with respect to the housing, such that upon relative rotation of the nut and the screw a linear movement of one of said nut and screw is obtained.

In certain applications, such as actuators for disc brakes, clutches etcetera, it is desirable to limit the overall dimensions and possibly the weight as much as possible. According to the invention, a compact layout may be obtained in that at least a rotatable component of the drive, e.g. the rotor of the motor, is rotatably supported on the screw which is rotatably supported with respect to the housing.

In particular, in case the screw is rotatably supported with respect to the housing by means of a support bearing, the screw may be integrated with the outer ring of the support bearing, such that the rotor of the motor, by means of an auxiliary bearing, is rotatably supported on the outer ring of the support bearing.

The support bearing is preferably accommodated with the auxiliary bearing. In such embodiment, a compact and stiff support for the rotor and screw is obtained.

The linear movement provided by the actuator usually generates a force, e.g. in the case of a disc brake for clamping the brake pads onto the brake disc.

As a result of the inevitable flexibility of the actuator and the system to which said actuator is connected, elastic deformations are also generated.

In so far as these deformations are axial-symmetric with respect to the screw mechanism, no problems occur as to the proper function of the actuator. However, in certain cases, and in particular in the case of disc brakes, loads are generated which are eccentric with respect to the actuator.

The eccentricity is to be attributed to the asymmetric shape of the brake calliper, in particular of the claw piece thereof which carries the brake pads and which accommodates the brake disc sideways.

Upon pressing the brake pads onto the brake disc, the claw piece is loaded in bending, which bending action is also transferred onto the housing of the actuator. As the screw mechanism is supported within the housing, said mechanism may become exposed to bending as well.

The screw mechanism is however rather vulnerable with respect to misaligned forces, in such a way that the proper function may be hampered and that damage may occur.

5 The object of the invention is therefore to provide an actuator of the type described before, which is less vulnerable with respect to misaligned forces. This object is achieved in that the screw mechanism is supported with respect to the housing by means of a joint which allows rotations about at least one axis transverse with respect to said linear movement.

10 In case the housing of the actuator is loaded in bending, said bending action is relieved as a result of the freedom of the screw mechanism to rotate around the transverse axis or axes. Thus, the screw mechanism will not be exposed to misaligned forces.

15 In particular, one of the nut and screw is rotatably supported both according to an axis parallel with respect to said linear movement, and according to at least one axis transverse with respect to said linear movement. Said transverse rotation may be obtained by means of a ball joint.

Said ball joint may be situated at one end of a central support shaft, the other end of which is connected to the housing. According to a preferred embodiment, said ball joint may be connected to a support bearing supporting one of the nut and the screw, 20 said one of the nut and the screw being drivably connected to the rotor of the motor.

The motor, preferably an electric motor, may engage the screw mechanism in several different ways. Usually, said motor is also connected to the housing, which means that the connection between the motor and the screw mechanism is also exposed to the elastic bending action of the housing under brake load.

25 Misalignment can be avoided here in case the nut and the screw engages the rotor through a coupling which allows rotations about at least one axis transverse with relation to the linear movement.

Said coupling may comprise an internally toothed member as well as an externally toothed member having equal number of teeth. The bending action of the 30 housing can be accommodated in particular in case the teeth of the externally toothed member are convexly curved in a cross-section parallel to the linear movement, and in case the teeth of the externally toothed member are centred with respect to the ball joint.

A compact embodiment is obtained in case the outer ring of the bearing is integrated with an internally toothed member. The screw and the internally toothed member are at axially opposite ends of the outer ring.

Conveniently, the rotor of the motor is rotatably supported on the outer ring of the support bearing.

According to a first embodiment, the rotor engages an externally toothed member through a reduction gear mechanism. Preferably, the support bearing is supported on one end of a support shaft, the other end of which is connected to the housing, the externally toothed member being rotatably supported on said support shaft.

The invention will now be described with reference to the embodiments shown in the figures.

Figure 1 shows a first embodiment in longitudinal section.

Figure 2 shows an exploded view of the embodiment according to figure 1.

Figure 3 shows a second embodiment.

Figure 4 shows a third embodiment.

The actuator shown in figures 1 and 2 comprises a housing 1 containing a screw mechanism 2 and a motor 3. Said screw mechanism 2 comprises a nut 4 and a screw 5, provided with screw threads 6, 7 and which engage each other by means of a number of balls 8. At the location of the inserts 9, the balls are transferred between adjacent windings of the screw threads 6, 7.

The screw is integrated with the outer ring 10 of support bearing 11. The outer ring 10 has a larger diameter than the screw 5, for reasons of compactness of the actuator.

The inner ring 12 of the support bearing 11 is integrated with a ball joint 13. In particular, the inner ring has a spherical inner surface 14, which engages a ball 15 connected to the central support shaft 16.

Although the ball 15 is depicted as a separate part, it may also be carried out in one piece with the central support shaft 16. The central support shaft 16 is connected to the housing through the clip ring arrangement 17, and load cell 18 for measuring axial forces.

The rotor 19 of the motor 3 is supported with respect to the outer ring of the support bearing 11 by means of a sleeve 31 having integrated bearings 20. Said sleeve 31 is fixed to the stator 21. The stator 21 of the motor 3 is fixably connected to the

housing 1. Furthermore, the sleeve 31 is fixed to sleeve 32 of a reduction gear wheel mechanism 22.

By means of the reduction gear wheel mechanism 22, the motor 3 drives the sleeve 23, which carries an outwardly toothed member. This outwardly tooth member  
5 has teeth 25, which have a curved shape.

The outer ring 10 of the support bearing 11 carries an inwardly toothed member 26, which carries inwardly directed teeth with a correspondingly curved shape.

The number of outwardly directed teeth 25 and inwardly directed teeth 27 is equal. These teeth engage each other so as to transfer the driving action from the sleeve  
10 23 onto the screw 5.

The nut 4 is carried out as a piston which is slidably held in a cylindrical space 28 in the housing 1. By means of pin 29 and groove 30 in the cylinder, said cylinder is held axially movable, but non-rotatable within the cylinder space 28.

Upon actuating the screw 5, the nut is therefore driven linearly and in axial  
15 direction with respect to the housing 1, e.g. for driving the brake pads of a brake calliper (not shown) towards and from each other.

In case, as a result of the forces generated in the housing 1, e.g. the housing of a brake calliper, a flexible bending is imposed thereon, the screw mechanism 2 is still protected against such loadings. Generally, screw mechanisms have a poor resistance  
20 against bending action, and the screw mechanism 2 in question is relieved from any bending loads due to the ball joint 13.

Also, the driving connection between motor 3 and screw mechanism 2 is relieved from any bending loads due to the teeth drive of the inwardly tooth member 26 and the outwardly tooth member 24, and the curved shape of the teeth in question.  
25 The embodiment of figure 3 shows a brake calliper 40, comprising a housing 1 connected to claw piece 41 by means of screw thread. At its side facing the actuator 1, the claw piece 41 has a cavity 43 in which part of the stator 21 of motor 3 has been accommodated. Thereby, a very compact brake calliper 40 is obtained.

As usual, the claw piece 41 has a fixed brake pad 44 as well as a movable brake  
30 pad 45 which is connected to the nut 5 of the screw mechanism 2, in particular to the head 46 thereof.

Between the brake pads 44, 45, a brake disc 47 is accommodated.  
The support shaft 16 supports the support bearing 11, the inner ring 12 thereof being

fixedly connected by means of e.g. a clip ring 48.

In this embodiment, the inner ring 12 of support bearing 11 has a closed head 49, such that a load cell 50 can be accommodated between said closed head 49 and the facing end of support shaft 16.

5       The other components of this embodiment are to a large extent identical to the embodiment of figures 1 and 2.

10       In the embodiment of figure 4, it is shown that the external teeth 25 of the externally toothed member 24 are rounded off in longitudinal cross-section, so as to better allow bending deformations of the housing, without however transferring the bending action onto the screw mechanism 2.

A grease-dosing unit 53 is accommodated in the base of the screw 5.

Claims

1. Actuator, comprising a housing (1) accommodating a screw mechanism (2) and a drive comprising a motor (3), said screw mechanism (2) comprising a nut (4) and a  
5 screw (5) one of which is rotatably supported with respect to the housing (1), such that upon relative rotation of the nut (4) and the screw (5) a linear movement of one of said nut (4) and screw (5) is obtained, characterised in that at least a rotatable component of the drive, e.g. the rotor (19) of the motor (3), is rotatably supported on the screw (5) which is rotatably supported with respect to the housing.
- 10 2. Actuator according to claim 1, wherein the screw (5) is rotatably supported with respect to the housing (1) by means of a support bearing (11).
3. Actuator according to claim 2, wherein the rotatable component of the drive, e.g. the rotor (19) of the motor (3) is rotatably supported on the screw (5) by means of an auxiliary bearing (52).
- 15 4. Actuator according to claim 3, wherein the support bearing (11) is accommodated within the auxiliary bearing (52).
5. Actuator according to claim 2, 3 or 4, wherein the screw (5) is integrated with the outer ring (10) of the support bearing (11).
6. Actuator according to claim 5, wherein the outer diameter of the outer ring (10)  
20 of the support bearing (11) is larger than the outer diameter of the screw (5).
7. Actuator according to any of claims 2 - 6, wherein the outer ring (10) of the bearing (11) supports a rotatable sleeve (31) which is in connection with the rotatable component (19) of the drive.
8. Actuator according to claim 7, wherein the sleeve (31) comprises, or is connected  
25 to, the integrated outer ring of an auxiliary bearing, the inner ring of which is integrated with the outer ring (10) of the support bearing (11).
9. Actuator according to claim 8, wherein the sleeve (31) comprises two axially spaced raceways, each of said raceways engaging a number of rolling elements (20) which each engage a raceway on the outer surface of the outer ring (10) of the support  
30 bearing (11).
10. Actuator according to claim 7, 8 or 9, wherein the sleeve (31) is connected to the rotor (19) of the motor (3).
11. Actuator according to any of the preceding claims, wherein one of the nut (4) and



screw (5) is rotatably supported both according to an axis parallel with respect to said linear movement, and according to at least one axis transverse with respect to said linear movement.

12. Actuator according to claim 11, wherein one of the nut (4) and screw (5) is supported with respect to the housing by means of a ball joint (13).

13. Actuator according to claim 12, wherein the ball joint (13) is at one end of a central support shaft (16), the other end of which is connected to the housing (1).

14. Actuator according to claim 13, wherein the ball joint (12) is connected to a support bearing (11), said support bearing (11) supporting the screw (5), said one of the nut (4) and the screw (5) being drivably connected to the rotor (19) of the motor (3).

15. Actuator according to claim 14, wherein said one of the nut (4) and the screw (5) engages the rotor (19) through a coupling (25, 27) which allows rotations about at least one axis transverse with relation to the linear movement.

16. Actuator according to claim 15, wherein the coupling comprises an internally toothed member (26) as well as an externally toothed member (24) having equal number of teeth (25, 27).

17. Actuator according to claim 16, wherein the teeth (25) of the externally toothed member (24) are convexly curved in a cross-section parallel to the linear movement.

18. Actuator according to claim 16 or 17, wherein the teeth of the externally toothed member (24) are centred with respect to the ball joint (13).

19. Actuator according to any of claims 14-18, wherein the screw (5) is integrated with the outer ring (10) of the support bearing (11).

20. Actuator according to claim 19, wherein the outer diameter of the outer ring (10) of the support bearing (11) is larger than the outer diameter of the screw (5).

21. Actuator according to claim 19 or 20, wherein the outer ring (10) of the support bearing (11) is integrated with an internally toothed member (26).

22. Actuator according to claim 20, wherein the screw (5) and the internally toothed member (26) are at axially opposite ends of the outer ring (10) of the support bearing (11).

23. Actuator according to any of claims 19-22, wherein the rotor (19) of the motor (3) is rotatably supported on the outer ring of the support bearing (11).

24. Actuator according to claim 23, wherein the rotor (19) engages an externally toothed member (24) through a reduction gear mechanism (22).

25. Actuator according to claim 24, wherein the support bearing (11) is supported on one end of a support shaft (16), the other end of which is connected to the housing (1), the externally toothed member (24) being rotatably supported on said support shaft (16).
- 5 26. Actuator according to claim 19 or 20, wherein the rotor of the motor directly engages the outer ring of the support bearing.
27. Actuator according to claim 26, wherein the rotor is integrated with an internally toothed member, and the outer ring of the support bearing is integrated with an externally toothed member, said members engaging each other.
- 10 28. Actuator according to claims 13-27, wherein the screw (5) and the support shaft (16) each have a throughgoing bore, said bores being aligned with respect to each other.
29. Actuator according to any of claims 1-28, wherein the screw (5) comprises a bore, said bore containing a grease dosing unit (53).
- 15 30. Actuator according to any of the preceding claims, wherein at least one of the components of the screw mechanism, support bearing, auxiliary bearing and reduction gear mechanism comprises a surface obtained by hard turning.
31. Actuator according to any of the preceding claims, wherein at least one of the components of the screw mechanism, support bearing, auxiliary bearing and reduction
- 20 gear mechanism comprises a coating, e.g. a diamond-like carbon coating.
32. Actuator according to any of the preceding claims, wherein an encoder is provided for measuring a relative rotation.
33. Brake calliper for a disc brake, comprising a claw piece carrying at least two opposite brake pads which enclose a gap for accommodating a brake disc, and an
- 25 actuator according to any of the preceding claims, said actuator having a housing accommodating a screw mechanism and a drive comprising a motor, said screw mechanism comprising a nut and a screw one of which is rotatably supported with respect to the housing, such that upon relative rotation of the nut and the screw a linear movement of one of said nut and screw is obtained, said housing being connected to the
- 30 claw piece, characterised in that at least a rotatable component of the drive, e.g. the rotor of the motor, is rotatably supported on the nut or screw which is rotatably supported with respect to the housing.

fig - 1

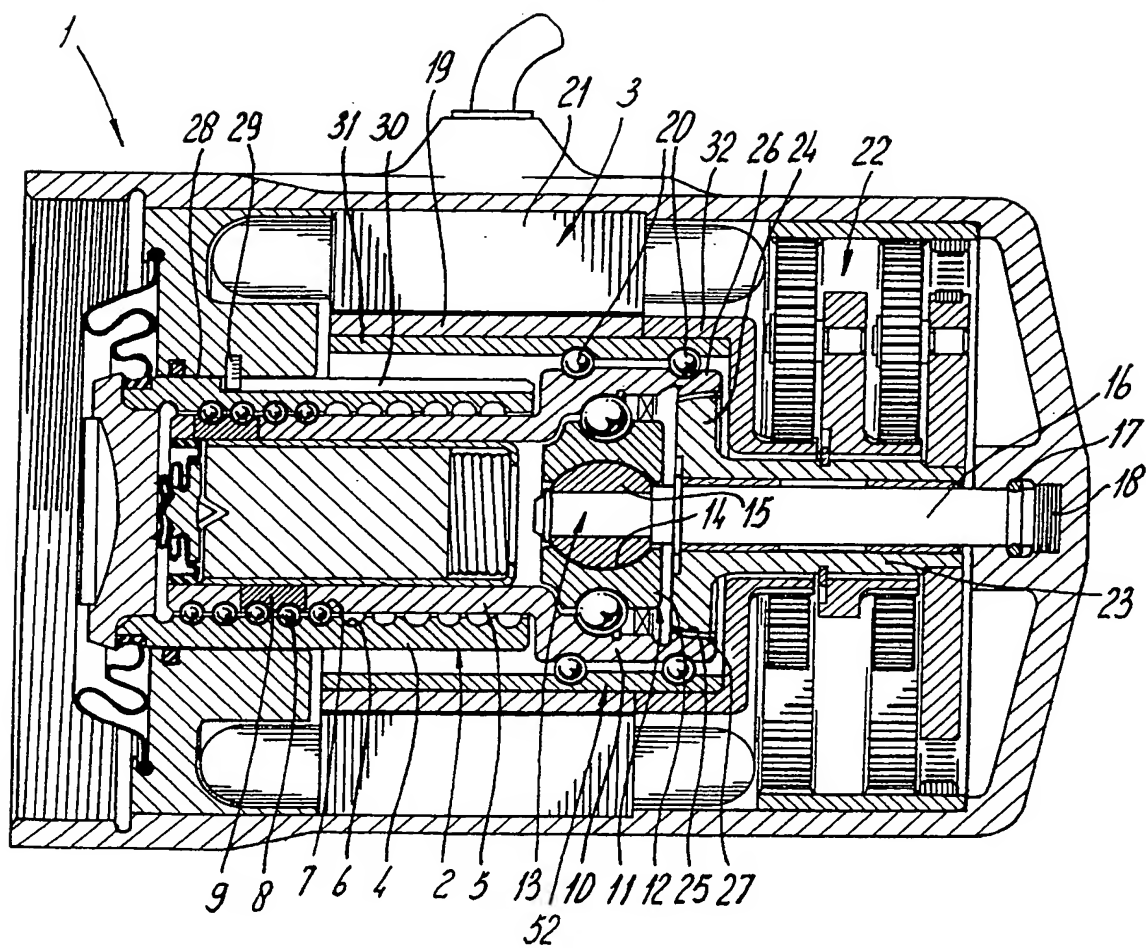


fig-2

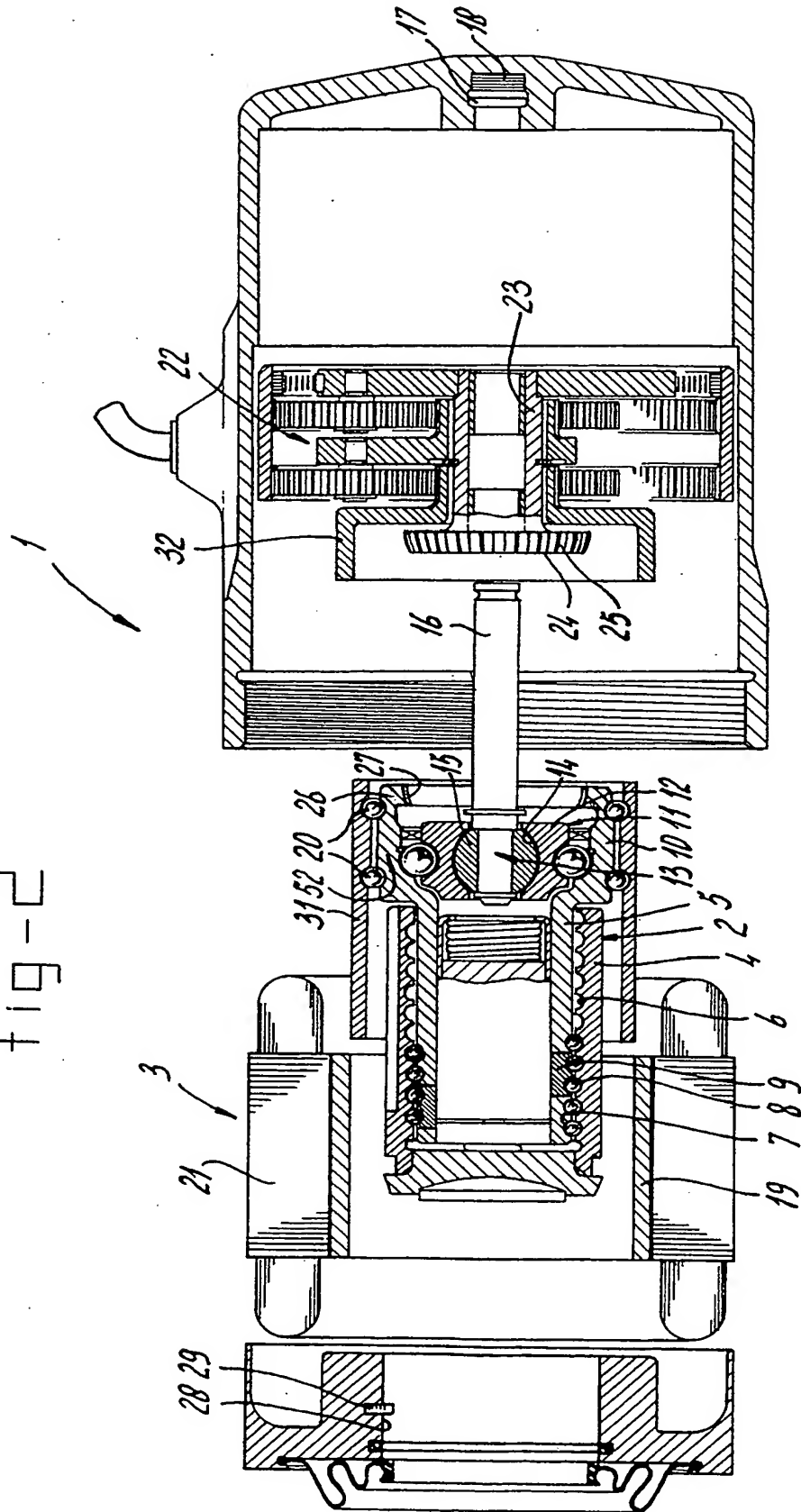


fig-3

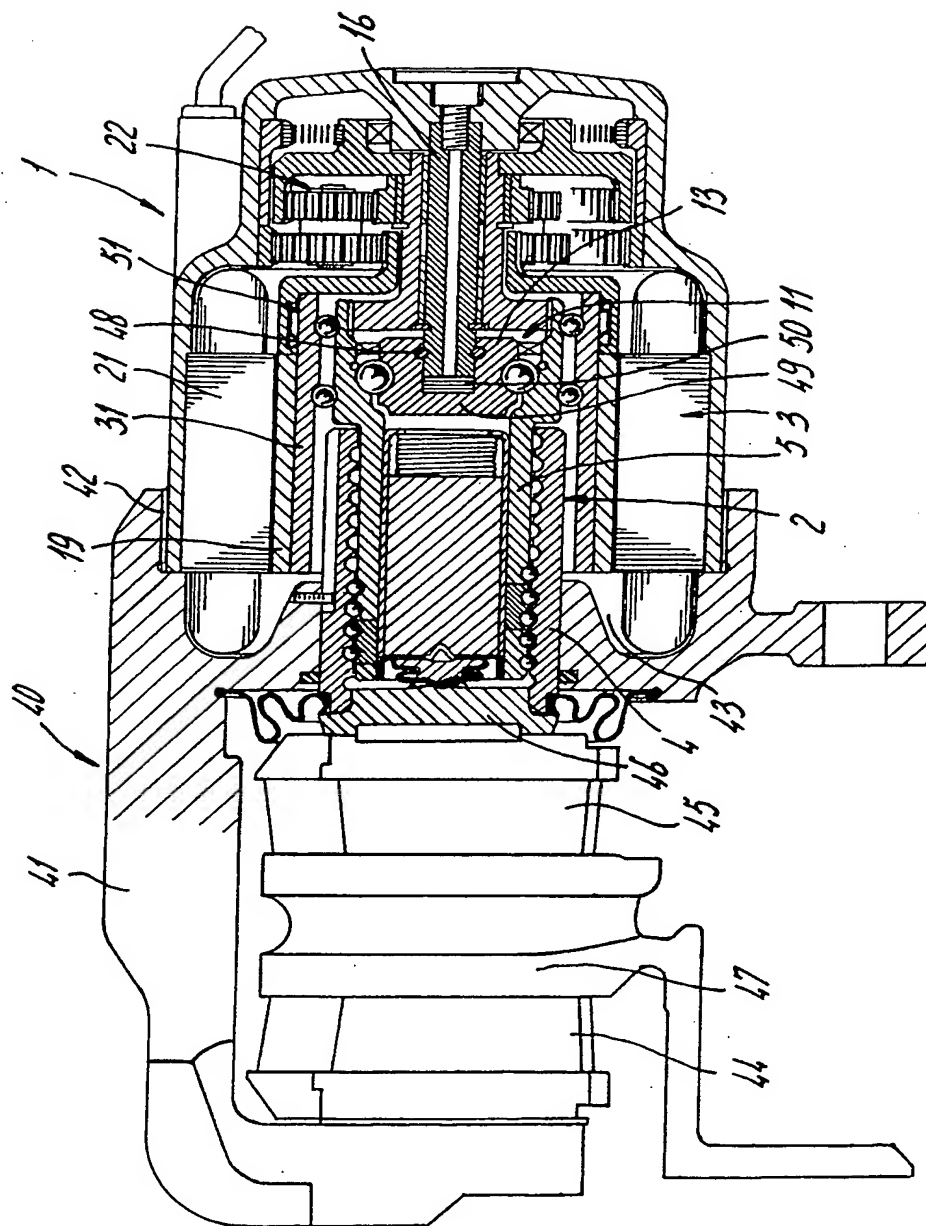
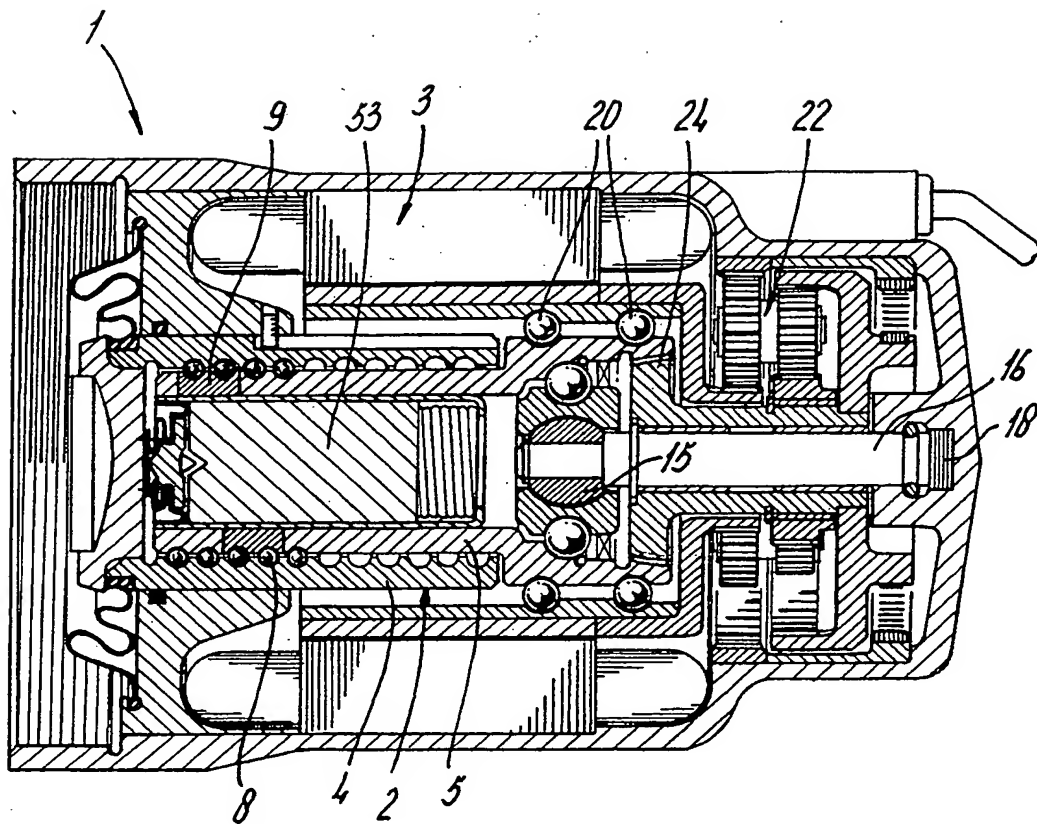


fig-4



## INTERNATIONAL SEARCH REPORT

International Application No

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**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 F16D65/16 H02K7/06

According to International Patent Classification (IPC) or to both national classification and IPC

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Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F16D F16H H02K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 196 52 230 A (ITT AUTOMOTIVE EUROPE) 18 June 1998 (1998-06-18) column 4, line 20 - line 26; figure 1	1
A	US 4 987 788 A (BAUSCH) 29 January 1991 (1991-01-29) claim 1; figure 2	1

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

Int'l Application No

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